MASTER OF SCIENCE
IN
AERONAUTICAL ENGINEERING

SOLID MODELING FOR ROTARY WING DESIGN AT NPS WITH AUTOCAD R13

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This thesis is intended to be a reference for solid modeling and Computer Aided Design (CAD) tailored specifically for the Naval Postgraduate School's capstone helicopter design course, AA 4306. The goal is to present the use of AutoCAD R13 software as a central design tool throughout the conceptual design phase of the American Helicopter Society (AHS) Graduate Design Competition project. The specifics of AutoCAD that are essential to performing the design project are explored through examples of model construction and lessons learned from the 1997 VIPER design effort. The usage of solid modeling as a design tool for design team integration is investigated. It is intended for this work to allow future classes to acquire sufficient proficiency with CAD and solid modeling. Maximizing the practical usage of CAD techniques in a single quarter will provide for an improved learning experience in a more realistic design environment.

KEYWORDS: AutoCAD, Design, Solid Modeling, Helicopter, Rotary Wing

DoD KEY TECHNOLOGY AREAS: Air Vehicles, Computing and Software, Modeling and Simulation

FLIGHT TESTING AND REAL-TIME SYSTEM IDENTIFICATION ANALYSIS OF A UH-60A BLACK HAWK HELICOPTER WITH AN INSTRUMENTED EXTERNAL SLING LOAD

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Helicopter external air transportation plays an important role in today's world for both military and civilian helicopters, external sling load operations offer an efficient and expedient method of handling heavy, oversized cargo. With the ability to reach areas otherwise inaccessible by ground transportation, helicopter external load operations are conducted in industries such as logging, construction, and fire fighting, as well as in support of military tactical transport missions. Historically, helicopter and load combinations have been qualified through flight testing, requiring considerable time and cost. With advancements in simulation and flight test techniques, there is potential to substantially reduce costs and increase the safety of helicopter sling load certification. Validated simulation tools make possible accurate prediction of operational flight characteristics before initial flight tests. Real-time analysis of test data improves the safety and efficiency of the testing programs. To advance these concepts, the U.S. Army and NASA, in cooperation with the Israeli Air Force and Technion, under a Memorandum of Agreement, seek to develop and validate a numerical model of the UH-60 with sling load and demonstrate a method of near real-time flight test analysis. This thesis presents results from flight tests of a U.S. Army Black Hawk helicopter with various external loads. Tests were conducted as the U.S. first phase of this MOA task. The primary load was a container express box (CONEX), which contained a compact instrumentation package. The flights covered the airspeed range from hover to 70 knots. Primary maneuvers were pitch and roll frequency sweeps, steps, and

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doublets. Results of the test determined the effect of the suspended load on both the aircraft's handling qualities and its control system's stability margins. Included were calculations of the stability characteristics of the load's pendular motion. Utilizing CIFER® software, a method for near real-time system identification was also demonstrated during the flight test program.

KEYWORDS: Helicopter, External Loads, Sling Loads, Flight Testing, CIFER, Real-time Data Analysis, Helicopter Handling Qualities, Helicopter Stability Margins, UH-60A, Black Hawk

DoD TECHNOLOGY AREAS: Air Vehicles, Modeling and Simulation

SPACE-BASED RADAR AND ITS IMPACT ON AIRCRAFT SUSCEPTIBILITY

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Since the U.S. does not have the largest military force in the world, it relies on force multipliers to achieve victory. One of these force multipliers is stealth technology. However, when stealth technology is used in modern military aircraft, usually only the forward sector of the aircraft is treated and/or shaped. This forward sector treatment is effective against static, ground-based radars. However, the aircraft may be very susceptible to a look-down type of radar. This thesis addresses the viability of using space-based radar to detect stealth aircraft.

Many papers have been written on how to use space-based radar to detect and track targets. However, these papers neglect to develop the satellite constellation that would be necessary to provide continuous radar coverage. These papers also do not address how susceptible stealth aircraft would be to space-based radar. The approach of this thesis was to select a target area, in the case Iraq, and develop two satellite constellations that could provide the required radar coverage. The next step was to determine if the system would be able to detect and track stealth targets.

Based on the analysis, one satellite in geosynchronous orbit can detect stealth aircraft. However, because the satellite is 35,786 km away, the power requirements, as well as the spot size are too large to track stealth aircraft. On the other hand, a constellation of 32 satellites in low earth orbit (1000 km) can both detect and track stealth aircraft. In conclusion, if the U.S. does not start applying stealth technology to the upper surface of stealth aircraft, they will be susceptible to space-based radar.

KEYWORDS: Space, Radar, Satellite

DoD KEY TECHNOLOGY AREAS: Space Vehicles, Sensors